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IoT Based Smart Home Automation and Security Monitoring System

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ABSTRACT

The rapid development of Internet of Things (IoT) technology has significantly transformed modern home environments by enabling intelligent monitoring and remote control of household appliances. This paper presents an IoT based smart home automation and security monitoring system designed using ESP32 microcontroller technology, relay modules, sensors, and wireless communication. The proposed system allows users to remotely control electrical appliances such as lights, fans, and other household devices using a smartphone application. The system also includes environmental monitoring features such as temperature sensing, gas leakage detection, and motion detection for enhanced safety and security. Sensor data and device status are continuously monitored and can be accessed through a mobile application interface. Whenever abnormal conditions such as gas leakage or unauthorized movement are detected, the system activates a buzzer alert mechanism to notify the user immediately. The developed system is low-cost, user-friendly, energy-efficient, and suitable for smart home applications. The proposed model improves convenience, safety, automation, and energy management in modern residential environments.

Keywords: IoT, Smart Home, Home Automation, ESP32, Relay Module, PIR Sensor, Gas Sensor, Mobile Application, Smart Security.

1. INTRODUCTION

The Internet of Things (IoT) has emerged as one of the most important technologies in modern communication and automation systems. IoT enables physical devices to communicate with each other through the internet, allowing real-time monitoring, remote access, and intelligent automation. One of the most popular applications of IoT technology is smart home automation. Smart home systems improve convenience, security, energy efficiency, and comfort by automating household appliances and enabling remote control through smartphones or other connected devices.

Traditional home systems require manual operation of electrical appliances such as lights, fans, air conditioners, and security systems. These methods consume more energy and are less efficient because appliances may remain active unnecessarily. In addition, traditional security systems provide limited monitoring and delayed response during emergency situations. Therefore, there is a growing need for intelligent home automation systems that provide real-time monitoring and remote operation.

Recent advancements in microcontrollers, wireless communication, and sensor technologies have made home automation systems more affordable and reliable. Smart home systems can now integrate sensors such as temperature sensors, gas sensors, and motion detectors to monitor environmental conditions continuously. These systems also provide mobile application support for remote operation and monitoring.

This paper presents an IoT based smart home automation and security monitoring system using ESP32 microcontroller and wireless communication technology. The proposed system enables users to remotely control home appliances while simultaneously monitoring environmental and security conditions in real time.

2. PROBLEMSTATEMENT

Modern homes face several challenges related to appliance management, energy consumption, and security monitoring. Some major problems are:

- Manual control of electrical appliances leading to energy wastage.
- Lack of remote access and monitoring capabilities.
- Absence of real-time gas leakage detection system
- Difficulty in monitoring home security while users are away.
- Lack of automated alert systems during emergencies such as fire or intrusion.
- High installation cost of commercial smart home systems.

Due to these issues, there is a requirement for a cost-effective and intelligent home automation system capable of remote monitoring, appliance control, and security management.

3. PROPOSED SYSTEM

The proposed system is an IoT based smart home automation and security monitoring system developed using ESP32 microcontroller technology. The system allows users to remotely control household appliances using a smartphone application connected through Wi-Fi communication.

The system includes relay modules for switching electrical appliances such as lights and fans. Environmental monitoring is performed using multiple sensors including a DHT11 sensor for temperature and humidity monitoring, MQ-2 gas sensor for smoke and gas leakage detection, and PIR sensor for motion detection. The ESP32 microcontroller continuously reads sensor values and uploads the data to the IoT platform for monitoring.

Whenever abnormal conditions such as gas leakage or unauthorized motion are detected, the system activates a buzzer alarm to alert users immediately. Users can monitor appliance status and environmental conditions remotely through a mobile application interface. The proposed system improves home automation by combining appliance control, environmental monitoring, and security management into a single integrated platform.

4. SYSTEM ACHITECHURE

The proposed smart home automation system consists of different functional units that work together for appliance control and environmental monitoring.

Sensing Unit

The sensing unit includes sensors used for collecting environmental and security related information:

- DHT11 sensor for temperature and humidity monitoring.
- MQ-2 gas sensor for smoke and gas leakage detection.
- PIR sensor for human motion detection.

Processing Unit

The processing unit consists of the ESP32 microcontroller, which processes sensor readings, controls relay outputs, and manages wireless communication.

Appliance Control Unit

The appliance control unit includes relay modules connected to electrical appliances such as lights and fans. The relays enable switching operations through mobile commands.

Alerting Unit

The alerting unit contains a buzzer that generates warning alerts whenever hazardous conditions such as gas leakage or unauthorized motion are detected.

IoT Communication Unit

The ESP32 connects to a Wi-Fi network and sends sensor data to an IoT dashboard or mobile application for remote monitoring and control.

Mobile Application Unit

The mobile application provides users with a graphical interface for monitoring sensor values and controlling appliances remotely.

5. HARDWARE REQUIREMENTS

Table

Component	**Hardware Compoents Used** Function / Purpose
ESP32 Microcontroller	Main controller and Wi-Fi communication
Relay Module	Controls electrical appliances
DHT11 Sensor	Measures temperature and humidity
MQ-2 Gas Sensor	Detects smoke and gas leakage
PIR Motion Sensor	Detects human movement
Buzzer	Provides warning alerts
LED Buld	Represents home lighting system
DC Fan	Represents home cooling appliance
Power Supply	Provides electrical power to system
Smartphone	Remote monitoring and control

6. SOFTWARE REQUIREMENTS

The software tools required for the implementation are:

- Arduino IDE for programming the ESP32 microcontroller.
- Embedded C / Arduino programming language.
- Blynk IoT platform or Firebase for remote monitoring.

- Mobile application for appliance control.
- Wi-Fi communication network.

7. WORKING METHODOLOGY

The working process of the proposed system is explained as follows:

- The system is powered ON and all sensors are initialized.
- ESP32 establishes Wi-Fi communication with the mobile application or IoT platform.
- Sensors continuously monitor environmental conditions such as temperature, humidity, gas leakage, and motion detection.
- Sensor values are processed by the ESP32 microcontroller.
- Users can remotely control appliances such as lights and fans using the mobile application.
- Relay modules switch appliances ON or OFF according to user commands.
- Sensor readings are uploaded to the IoT dashboard for monitoring.
- If gas leakage is detected, the buzzer alert system is activated immediately.
- If unauthorized motion is detected, the system generates a security alert.
- The process repeats continuously for real-time automation and monitoring.

8. ALGORITHM

Step 1: Start the system.
Step 2: Initialize ESP32, DHT11 sensor, MQ-2 sensor, PIR sensor, relay module, and buzzer.
Step 3: Connect ESP32 to Wi-Fi network.
Step 4: Read temperature and humidity values from DHT11 sensor.
Step 5: Read gas sensor values from MQ-2 sensor. Step 6: Read motion detection status from PIR sensor. Step 7: Upload sensor readings to IoT dashboard.
Step 8: Receive appliance control commands from mobile application.
Step 9: Switch appliances ON/OFF using relay module.
Step 10: If gas leakage is detected, activate buzzer alert. Step 11: If motion is detected, generate security alert.
Step 12: Repeat the process continuously.

9. RESULTS AND DISCUSSION

The proposed IoT based smart home automation and security monitoring system was implemented and tested successfully under different environmental conditions. During testing, the system was able to remotely control electrical appliances such as lights and fans using a mobile application interface.

The DHT11 sensor continuously monitored room temperature and humidity values accurately. The MQ-2 gas sensor successfully detected smoke and gas leakage conditions and activated the buzzer alert mechanism immediately after the threshold value was exceeded. The PIR sensor successfully detected human movement and generated security alerts

The ESP32 microcontroller uploaded sensor readings and appliance status to the IoT monitoring dashboard in real time through Wi-Fi communication. The relay modules responded quickly to user commands and switched appliances reliably. The system

demonstrated stable performance, low power consumption, and efficient operation for smart home automation applications.

10. ADVANTAGES OF PROPOSED SYSTEM

The major advantages of the proposed system are:

- Remote control of household appliances.
- Real-time environmental monitoring.
- Low-cost implementation using IoT technology.
- Improved home security through motion detection.
- Immediate gas leakage detection and alert system.
- Energy efficient appliance management.
- User-friendly smartphone interface.
- Wireless communication and remote access.
- Easy installation and scalability.

11. APPLICATIONS

The proposed system can be applied in:

- Smart home automation systems.
- Residential energy management systems.
- Home security monitoring systems.
- Office and commercial building automation.
- Elderly and disabled person assistance systems.
- Industrial monitoring and appliance control.

12. CONCLUSION

This paper presented an IoT based smart home automation and security monitoring system developed using ESP32 microcontroller technology and wireless communication. The proposed system enables users to remotely monitor and control household appliances using a smartphone application. The system also provides environmental monitoring and security features using sensors such as DHT11, MQ-2, and PIR sensors.

The developed system improves convenience, energy efficiency, and home security while maintaining low implementation cost. Real-time monitoring and remote accessibility make the system suitable for modern smart home applications. The results indicate that the proposed system is reliable, efficient, scalable, and effective for home automation and security management.

13. FUTURE SCOPE

The proposed system can be enhanced further by:

- Integrating voice assistants such as Alexa or Google Assistant.
- Adding AI based energy optimization algorithms.
- Integrating smart door lock systems.
- Using cloud storage for data analytics and monitoring.
- Implementing solar energy monitoring and management.
- Adding fire detection and automatic emergency response systems.
- Adding smart irrigation and water management features.

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